GLOBAL CLIMATE CHANGE AND SOLUTIONS FOR URBAN SUSTAINABILITY OF HO CHI MINH CITY, VIETNAM

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Abstract

Ho Chi Minh City (HCMC), the largest city in Vietnam, is steadily growing, certainly towards a mega city in the near future. Like other mega cities at the boom stage, it has to face with serious environmental matters insolvable for many years. The situation may be worse under the effects of global climate change, geological subsidence due to non-standard construction and sea level rise. The situation of HCMC can be damaged or even broken by resonant effects of unsolved environmental matters and latent impacts of climate change. This article shows the challenges to the urban sustainable development under the duo effect of urban environmental matters and climate change in Ho Chi Minh City. Opportunities and strategic directions to overcome the challenges are also analyzed and recommended.

Keywords: climate changes, urban sustainability, Vietnam

1 INTRODUCTION

HCMC has got involved in high-speed urbanization and therefore, it has suffered the dark side of development policies and has to face with more and more complicated environmental matters. Resource degradation and environmental pollution in the city are common. Even though the community and authorities have made many efforts to react to urgent matters of the environment, the general situation is not yet improved.

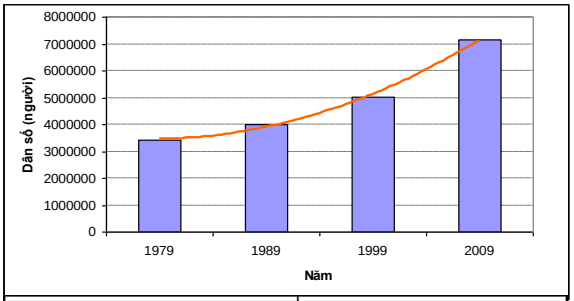
Besides, as one of coastal cities of Vietnam, HCMC is also vulnerable to climate change and sea level rise. The inextricable environmental matters of the city may be severer because of abnormal changes in weather factors as a result of global climate change. The urban sustainability of HCMC may be damaged or even broken by resonant effects of unsolved environmental matters and latent impacts of climate change there. Urban sustainable development is therefore a target and key work of HCMC authorities. The target can be reached based on resource preservation, and reasonable use of soil and water sources; good control of urban pollution and effective implementation of solutions to response to climate change in accord with the natural conditions of the city.

HCMC will certainly become a mega city (with more than 12 million people) in the near future. Therefore, together with the more and more apparent effects of climate change, there are big challenges to the sustainable development of the city in the context of increasing urbanization with more pressures from high-rise buildings and their consequences as well. Overcoming that challenge requires a new approach. At the same time, opportunities for sustainable development are significant. With natural conditions and ecological features of a coastal city, Ho Chi Minh City owns certain advantages for adapting itself to climate change, for instance, abundance of wet forests and tropical inland forests with the existence of Can Gio biosphere reserve, and Cu Chi historic forest. Moreover, the city has a large water surface with a rich and abundant system of rivers, canals, swamps, not to say bio-diverse riverine and estuarine ecosystems. The ecosystems are supportive and valuable in climate conditioning and pollution adsorption. It is essential and urgent to define, analyze adequately and correctly the challenges to sustainable development under the duo effects of urban environmental matters and global climate change in HCMC in order to sketch out suitable decisions in due time.

2 URBAN DEVELOPMENT CONTEXT AND ENVIRONMENTAL CHALLENGES IN HO CHI MINH CITY

Compared to other cities in Vietnam, the rate of urbanization of Ho Chi Minh City is very high. In 30 years (1979 to 2009), its population doubled (Figure 1). The official data in 2012 includes a population of 7,396,440 people, a density of 3530 people/km2, the highest in Vietnam (For instance, Hanoi: 1962; Hai Phong: 1221; Da Nang: 722; and Can Tho: 854). Nevertheless, about 3 million people should be taken into account. Those are frequent residents coming for study, short-term works, and informal workers. The nominal population density in urban districts is more than 12,000 people/km2, with 45.000/ km2 being the highest (in District 11). The urban population increased from 3,466,100 in 1995 to 6,157,600 in 2012 (i.e. approximately 178 %) [1].

This young and dynamic city is however developing too fast, missing steadfast and reasonable planning policies. As urban infrastructure development still lags behind the demand, informal urbanization is always underway, resulting in shortcomings of urban planning and management and many problems. In details:



1/10/1979	3419977
1/4/1989	3988124
1/10/1999	5037155
1/4/2009	7162864

Figure 1 Graph of population increase in HCMC

a) *Regarding urban planning*: The development is not going on as approved in the master plan. In fact, the city is not expanding to the South and Southeast as planned but to the West and Northwest, which is planned as reserve for agriculture. Most new urban centers and industrial parks, which are planned to be situated in the suburbs, actually never take shape while small and medium residential areas and industrial zones (absent in the approved master plan) are interposed in the urban area. Many construction works in the suburbs grew up without regulatory permit or any paper from authorities. According to a study by Shigehisa Matsumura (*Nikken Sekkei research institute*), out of construction works built up from 2001 to 2003, the ones without permit account for 66.7%. Whereas, the city has plenty more detailed plans, which are possibly causative of poor synchronization and consistence in land use and infrastructure exploitation [2].

b) *Urban land resource* overexploited for economic targets. Since the value of urban land is rocketing, no more attention is paid to land allocation for open spaces. The rates of parks, water and tree covers in urban areas are too low. Air pollution is increasing because of narrow urban roads and limited public land for entertainment and recreation. The linking of the urban system to the nature is at risk. In fact, the natural abundant system of rivers and canal is basically changed with riverside vegetation covers replaced by artificial embankments and anti-inundation surrounding dikes (see *Figure 2*), or with flows blocked (replaced with culverts); many rivers and lakes are already filled up for expanding urban land. According to the master plan in 1998, in the period of 1998 to 2005, 3,576 ha of canals would be filled up but in fact, by June 2006, the area of filling up under projects, i.e. land allocated and leased, was 5,157 ha [3]. In the period of 1998 to 2009, it is estimated that the old urban area lost 50% of its green cover and the density fell to 0.7 m^2 per capita in 2009 [4].

In 2004 In 2011

Figure 2 –Riverside ecosystems of the Saigon River has changed due to surrounding dikes

c) *Water resources*: Surface and underground water resources for water supply are more and more limited because of the mounting demand of the city and surroundings. According to the water supply master plan of Saigon Water Company (SAWACO), by 2015 and 2025 the total demands for water per day are 2.35 million m^3 and 3.15 million m^3, i.e. double and triple as high as the current one (1.34 million m^3). Unless a synchronous plan of water share between localities in the basin, particularly in cases of drought, such demands can hardly be satisfied. The water demand of HCMC till 2015, estimated at 3.2 million m^3 per day, then 4.1 million m^3 per day in 2025 is the main cause of overexploitation of underground water. At present, there are 96,000 tube wells of various capacity and depth in the city. The first sign of underground water level falling was found in 1996. Overexploitation of underground water, in the one hand, exhausts the resource, and in the other hand, is one of the main causes of ground subsidence. According to Le Van Trung [5], some monitoring wells in District 12 disclosed the visible correlation between ground subsidence and underground water level lowering from 1996 to 2010. In details, while the underground water level decreased 2-3 m per year, the ground subsided more than

>15 mm per year. According to statistical data of HCMC Department of Resources and Environment, the volume of underground water extracted per day is 524,500 m^3, whereas the capacity of safe exploitation is only 951,000m^3 per day. Worse still, some main waterworks intend to boost their exploitation of underground water. Furthermore, the actual exploitation of underground water by individuals is hard to control, and the trend of exhaustion is alarming [6].

d) *Urban inundation*: According to a report by the Operation Center for the anti-inundation program of HCMC, the program "*Anti-inundation in the rain season and environmental treatment in HCMC*" is underway since 2001 yet the situation is not improved yet. The number of spots inundated by rain is still large, particularly in the downtown. Clearance or reduction of spots inundated by tide is even more difficult; to date, only a couple of local tide-control projects are accomplished. Meanwhile, more inundated spots appear as a result of urbanization, particularly in newly developed areas and in the suburbs. Among various causes of inundation, in addition to natural factors (heavy rain, high tide, low terrain), two basic causes are pointed out by authorities: (i) no comprehensive master plan for urban drainage and (ii) failure of infrastructure to keep pace with the urbanization speed [6].

e) *Environmental planning*: Planning of urban environment is an indispensable and effective tool to control urban pollution. However, a comprehensive master plan with legal meanings for the city is still unavailable. That is certainly one of the causes of its poor environment, which can be detailed as (i) water quality of rivers and canals is not yet improved; (ii) air pollution is high; (iii) urban solid waste volume is increasing whilst the only method of treatment is land-filling with a large requirement of vacant land; (iv) control of industrial pollution is not strict enough; and (v) pollution due to infrastructure construction is obstinate.

3 DUO EFFECTS OF ENVIRONMENTAL MATTERS AND CLIMATE CHANGE ON URBAN SUSTAINABILITY OF HO CHI MINH CITY

The changes relating to climate change in the coming years are predicted by meteorologists for South Vietnam, including HCMC include:

- Temperature will be higher than the baseline of recent decades. It is probable that many localities will suffer new records of temperature maximum. Hot days in early months may be blazing, amplifying the drought intensity.
- Rainfall will increase in some places and decrease other places. In the far future, rainfall in the rainy season will be higher while that of the dry season will vary more. The most change is probably rainfall. Records of rainfall per day or a downpour may be the same as in the South of Central Vietnam.
- Evaporation will increase together with temperature and the drought index is likely to be higher and higher, particularly in the end of the dry season. Meanwhile, sea level will continue rising by 0.5-0.6cm per year.

Based on the predictions above, it is possible to define some negative factors that threaten the sustainability of cities in the South of Central Vietnam as follows: (i) High temperature together with the increase in temperature of urban surfaces because of change in the buffer will push up the maximum temperature in the hot and dry season to new records; (ii) the increasing rain intensity and high records of rainfall in a day or downpour will aggravate inundation in the city; (iii) higher evaporation and drought index together with sea level rise will push saline water farther to mainland and as a result, the resource of fresh water will become scarcer, particularly in years of drought. This, "*drought and inundation*" is a risk ahead to the sustainable development of HCMC. Main threats are analyzed in details with reference to researches of some scientists in HCMC.

3.1 Days of scorching sun may reach new records

The superficial temperature of urban areas increased due to concrete structures in the past 02 decades. According to a study by Tran Thi Van and Ha Duong Xuan Bao in 2008 [4], within 17 years (1989-2006) the surface area covered by concrete increased by 305.5% (from 6,000 ha in 1990 to 24,500 ha in 2006). In HCMC, it increased by 0.18^{o}C in the period of 1977 to 1986, 0.26^{o}C from 1978 to 1986 and 0.35^{o}C from 1997 to 2006; its maximum of 49.4^{o}C was recorded in 2006. In the scenario of air temperature increase, the maximum in HCM is much higher in the next decade. That will strongly affect the urban living. High temperature background in combination with air pollution in urban areas will boost diseases, particularly in the sector of low income and simple jobs (working outdoor). More power will be consumed for cooling in living and industrial activities while clean electricity sources (e.g. hydropower) are very limited in the dry season. Obliged upset from thermal power will eventually boost the emission of greenhouse gases.

3.2 Possibly fiercer inundation

According to Truong Van Hieu [7] urbanization and effects of climate change have changed microclimate of urban centers. There are significant changes in rain distribution and intensity. In the period of 1978-2007, the increase in rainfall in HCMC was 98 mm with higher values in suburban districts, for instance, 192 mm, 154 mm and 104 mm in Binh Chanh. Hoc Mon and Nha Be, respectively. The average increase in old urban districts was 63 mm. Rain came fast and ended fast with high intensity, the number of days with >25mm rainfall (i.e. causative of inundation) was high (23 days per years). Rains with more than 40 mm (11.3 days per year) usually had higher intensity with a shorter raining duration (mostly less than 120 minutes). With such a trend, inundation in urban areas and suburbs in the rainy season will be fiercer, particularly when a heavy rain coincides with flood tide.

Selection and realization of anti-inundation measures for the city will be more complicated, particularly for the spots where inundation is triggered by tide or tide in combination with heavy rains. At present, construction measures are preferred for anti-inundation, meaning that there is not comprehensive master plan for the whole city. Main works against tidal inundation are under construction, mostly surrounding dikes and embankments at lower zones, tide-control gates in combination with draining pumps. The designs of those construction works are in fact complicated problems because it is not easy to choose optimal data of rain and tide in order to ensure their long-lasting operations and effective investments. Abnormal ups and downs of rain and tide under effects of climate change make selection of designing data much more difficult. Environmentally, those construction works cause many negative impacts, the most apparent ones of which, include the loss of the riverside natural ecosystems, breakage of the natural rain drainage, obstruction of draining flows, and overall, high risks of onerous inundation after heavy rains and the resultant water pollution. Further, risks accidental to environmental incidents such as dike break, unworkable regulating gates in cases of a heavy rain coinciding with flood tide are very high. The economic and environmental consequences of such an even are immeasurable.

3.3 Safety of water supply may be threatened

Located downstream the Saigon – Dong Nai basin in a region of high-speed urbanization and industrialization, HCMC is facing with utmost challenges to safety of water supply for development. The strong growth of urban and industrial zones in the city and its vicinity necessitates a huge demand of water supply. Meanwhile, it is noteworthy that its water supply system lags behind urban development and the situation of water supply is really a problem more inextricable than ever. Moreover, the water resource in the region is limited, not to say some negative changes due to unfathomable effects of climate change. The exploitation and use of water in other localities in the basin are on the rise without overall control, making planning more complicated. The difficulties also include water sources, quality, distribution network planning and water supply management.

The dry season in HCMC lasts 6 months and is dependent upon monsoon circulation. Therefore, serious shortage of water in the years when the rainy season comes late is very common. Recent years of drought include 1998, 2005, 2010. Drought may be more vicious due to climate change. Water distribution in the basin, particularly drainage of large reservoirs (Dau Tieng, Tri An, and Phuoc Hoa, etc.) can cause water shortage in years of drought.

The expansion of urban and industrial zones to the South and Southwest of HCMC (to suburban districts such as Binh Chanh, Nha Be and Can Gio) require investments in a very large but ineffective water supply network. Worse still, water loss (always accompanying waterworks) is still an unsolved problem in HCMC. According to statistical data published by SAWACO, it is supplying approximately 1.2 million m^3 of clean water, of which 40% is lost, equivalent to 500,000m^3 per day, i.e. a double of the capacity of Thu Duc BOO waterworks. Even when efforts are made to cut down the rate of loss to 30% (according to the water supply plan of the city) in 2025, the volume of water loss will be as large as 0.6 million m^3 per day. In such a situation, safety of water supply is an inextricable problem and the city is day and night becoming a mega city out of control.

4 OPPORTUNITIES AND STRATEGY OF SUSTAINABLE DEVELOPMENT FOR HO CHI MINH CITY IN GLOBAL CLIMATE CHANGE

As mentioned above, challenges to the sustainable development of HCMC in the context of global climate change are real and big. Nevertheless, there are opportunities for overcoming those challenges that depend upon awareness of and attempts to preservation and protection of valuable urban resources; particularly the maintenance and consolidation of diverse natural ecosystems of the city. Among ecologist' parameters of urban sustainable development, there are 03 keys: (i) preservation of natural land form and terrain; (ii) protection and development of urban trees; and (iii) encouragement of water saving. HCMC can satisfy those parameters thanks to its favorable geographical and ecological conditions, including:

a) Development in a continuous space from mainland to estuary: The continuity of ecosystems together with the diversity of original ecosystems (monsoon tropical forests, wet land and forests on acid sulfate soil) are the significant upper hand for the city to exploit and restore the advantages of its natural conditions for growing as a city of high ecological diversity with favorable land for production, aesthetics and recreation.

b) Formation alongside big rivers with abundant canals from mainland to the sea: The city is located downstream the Dong Nai – Saigon River with a well developed system of canals and arroyos. In addition to main axis rivers from upstream to Ganh Rai gulf (i.e. Dong Nai, Saigon, Nha Be and Long Tau), the city has a system of interlacing system of natural canals and artificial canals of grades 3 and 4 (for instance, the Dong – Cu Chi canal and others such as An Ha, Xang and Binh Chanh). The system of rivers and canals from upper reaches to the sea has built up the abundance of aquatic biota and riverside vegetation covers, including wet land, brackish water ecosystems and fresh waters. In general, the system of rivers, canals and lakes create a very large water surface of the city. That is an especially favorable environmental condition that the city can take advantage in planning for environmental protection, making full use of its capacity to treat urban wastewater; and at the same time, maintaining the necessary open spaces, securing the demand for water storage and drainage when heavy consequences of climate change occur.

Considering the advantages above, some strategic orientations of measures for environmental protection and response to climate change are recommended below.

4.1 Preservation and development of urban forests in suburbs and outskirts.

HCMC holds valuable resources and large potentials for developing urban forests. Compared with other cities in Vietnam, HCM City has the best opportunity for expanding its green covers. The area of forest land in the city is 33,532.76 ha (including special use forests: 29.92 ha, protective forests: 33,860.00 ha; and protection forests: 2,293.16 ha). Under the project for protection and development of forests and trees in HCMC till the year 2020 and vision to the year 2025, the rate of areas covered by forests and trees should be at least 40% [8]. To reach that objective, the measures to be synchronously taken include: maintaining and boosting the area of forests and forested trees; boosting the area of urban trees and parks; maintaining the areas of trees alongside rivers, canals and sea dikes; keeping the area of agriculture land and developing urban agriculture in an environment-friendly manner (application of green productivity models).

4.2 Embedding urban planning in environmental planning.

It is essential to carry out a study for making an environmental master plan for the city, thereby environmental functions of every specific zone and districts are defined as the background for local environmental planning and management. Open spaces (green covers, water surfaces, infiltration areas, etc.) in urban areas should be expanded; and substitute plans for urban drainage should be studied and applied:

- Regarding spots inundated by rain (high terrain, in the north and northeast of the city): expansion of open spaces, regulating lakes, landscape lakes in accord with natural conditions; designing and construction of culverts with adequate capacity; construction of rain water tanks for large-roof works.
- Regarding zones inundated by tide (low terrain, riverside in the south and southeast, alongside the Saigon River in Thu Duc, Hoc Mon and District 12): maintaining riverside ecosystems, natural tidal inundated zones; avoiding rivers and canals of filling up; and developing elevated urban works (high buildings and overhead roads).
- Regarding zones inundated by rain, tide and flood discharge: clearance and re-arrangement of uncontrollable zones.

4.3 Collection of rain water for saving surface water resources and preserving underground water and reducing flows in urban areas.

An ecological approach is needed to solve the matters of water supply and inundation in HCMC in a basic and long-lasting manner. Main directions related to rain management are recommended as follows: (i) keeping as much as possible the natural and man-made systems of rivers, canals, and inundated zones in the city for regulating and draining storm water, and at the same time, boosting the capacity of dilution of urban waste entrained by storm water. That should be based on the principle as follows: *clear passage of natural flows in combination with regulation of heavy rains by means of lakes with a part of storm water reused for water supply*; (ii) quickly laying down as a policy and developing the program of rain water collection and use in the entire city.

Those measures need first a change in viewpoint and awareness of the rain water resource in the communities and authorities. Especially, it is necessary to be fully aware of the risk to "*drought and inundation*

in the city" under effects of climate change and the currently rapid urbanization. HCMC authorities should speed up and promote the communication about collection and use of rain water in communities with better knowledge and technologies by incorporating the program into education and training courses at various levels. Furthermore, a force of specialists, engineers and technicians in the field of **rain water collection** should be established and trained; mechanism of financial and technical supports should be built up for fostering the **rain water collection industry** in addition to a network of services of design, fabrication and installation of **rain water collection apparatus**; Systems of rain water collection should be step by step developed in urban areas at houses, tenement houses, buildings, service entities, schools, offices, and public works, etc.

5 CONCLUSIONS

Ho Chi Minh City is a dynamic city with high speed of urbanization and will become a mega city in a near future. Speedy urbanization pushes the city to face with many environmental matters, including shortcomings of urban planning, use of urban resources and environmental pollutions. In combination with effects of global climate change, those matters have threatened the urban sustainability of the city. The most apparent risks include more scorching days, fiercer inundation and drought, and endangered safety of water supply for urban and industrial development.

Nevertheless, opportunities for responding to climate change, solving urban environmental matters and avoiding the risks mentioned above are real because HCMC has favorable conditions of land, and more importantly, the support from its own ecological diversity. Preservation and development of forest resources, boosting green covers and urban water surfaces through the approach of designing together with the nature are basic solutions. Saving and optimal use of resources (forests, water, land, etc., particularly **management and use of rain water resource** is a decisive method to deal with the situation of "*inundation and drought in the city*" in the context of urban development and climate change in HCMC.

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